Labial Bone Thickness in Area of Anterior Maxillary Implants Associated with Crestal Labial Soft Tissue Thickness

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Objective: *To explore the relationship between implant's labial bone thickness (ILBT) and crestal labial soft tissue thickness (CLSTT).*

Materials and Methods: *This retrospective study used records of 32 (22 females and 10 males) patients who had 2 implants placed in their maxillary arch (64 implants; diameter range, 3.3–4.6 mm) between the canines at either maxillary lateral incisor (7 and 10) or central incisor (8 and 9) region. All patients had diagnostic and postoperative cone beam computed tomography scans; the ILBT at the crestal and midimplant levels were recorded. CLSTT was measured approximately 4 months after the placement of implants using a digital caliper at the crestal level.*

Results: *Mean (standard deviation) CLSTT and ILBT at crestal and at midimplant levels were 2.45 (0.88), 1.79 (0.68), and 2.33 (1.01) mm, respectively. Overall, 26 implants had prior bone augmentation. Significant relationships between the CLSTT and ILBT at crestal (Spearman's rho = 0.720) and midimplant levels (Spearman's rho = 0.707) were observed (P $<$ 0.001). The determination coefficients (R^2) between CLSTT and ILBT at crestal and midimplant levels were 0.649 and 0.542, respectively. Following regression equations were produced: CLSTT = 1.043 * ILBT (crestal level) + 0.586 and CLSTT = 0.955 * ILBT (midimplant level) + 0.955.*

Conclusion: *Based on this study, CLSTT and ILBT were highly associated in the anterior maxillary region. (Implant Dent 2012;21:406–410)*

Key Words: labial bone thickness, anterior maxillary implants, crestal labial region, soft tissue thickness

Soft tissue problems (ie, gingival recessions) are common in implantology and are often associated with thin soft tissue biotypes or buccally placed implants.[1] Goaslind et al[2] described 2 types of biotypes commonly found in the natural dentition: thick and thin. It has been suggested that thicker soft tissue biotypes are associated with less tissue recession,[3] higher crestal bone levels,[4] and better aesthetics.[5] A thin tissue biotype has been shown to be more prone to tissue recession.[3] Gingival recession is always associated with alveolar bone dehiscences.[6–11] Furthermore, there is evidence that thick soft tissue may be protective against crestal bone loss[4] (ie, tissue thickness of <2.5 mm resulted in crestal bone loss of 1.45 mm vs. thicker tissues had 0.26 mm). This protective effect occurred, despite the supracrestal position of the implant-abutment interface.[4] Jung et al,[5] using photospectometry, showed that soft tissue thickness of >2 mm is ideal to achieve natural aesthetic when using different abutment material, that is, when the tissue thickness was <2 mm, only zirconia resulted in the least amount of color change. As a result of these findings, many authors have recommended the routine use of connective tissue graft to thicken the labial soft tissue to >2 mm.[12,13] In particular, the recession of the facial mucosa is the main complication observed with immediate implants.[1,14–20]

Implant placement in aesthetic areas (ie, anterior maxillary teeth) is challenging,[21] and adequate labial or buccal bone thickness seems to be critical to prevent future bone dehiscence and marginal recession.[20,22] A 2 mm of facial bone thickness has been suggested as a minimum to prevent future recession.[20,22] So far, a direct relationship has not been demonstrated between the facial crestal level and marginal soft tissue recession.[23] The soft tissue recession around implants placed in the anterior maxilla is a major aesthetic issue, and determining the factors that affect the soft tissue thickness in this area is extremely important. The objective of this study was to explore the relationship between the thickness of labial bone in anterior

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ISSN 1056-6163/12/02105-406
Implant Dentistry
Volume 21 • Number 5
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DOI: 10.1097/ID.0b013e31826371b5

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maxillary implants and the crestal labial soft tissue thickness (CLSTT).

Materials and Methods

The material for this retrospective study comprised provisional study casts and sectional cone beam computed tomography (CT) images of 32 (22 females and 10 males) patients who were treated in the private practice of the first author. The material has been anonymized by the first author so that patients' information cannot be identified. As such, ethical approval for this study was not needed. These selected patients had to have 2 implants in the maxilla placed at the same time, between the canines at either maxillary lateral incisor (7 and 10) or central incisor (8 and 9) region. To be included in the study, patients must have had soft tissue casts available at the time of temporization. The provisionals typically arrived with the soft tissue moulage in the cast. Those implants for which soft tissue casts were not available or not obtainable from the laboratory were excluded. Overall, 64 implants were placed. Implant diameters ranged from 3.3 to 4.6 mm. The implant position was determined using the cone beam CT image (Picasso Duo; VATech, South Korea) and by measuring the total ridge width and comparing the diameter of the implant and the surrounding bone thickness (labial bone, palatal bone). All patients had diagnostic (pre) and postoperative sectional cone beam CT scans. Using the sectional cone beam CT images, the labial bone thickness at the crestal (2 mm from the bone crest) and midimplant levels were measured and recorded (Fig. 1). The CLSTT was measured using a digital caliper (Mitutoyo) on study casts, at the time of temporization, at the crestal level (Fig. 2). Prior implant site augmentation was also recorded. The measurements of CLSTT were performed approximately 4 months after the placement of implants. All measurements of the CLSTT, labial bone thickness at the crestal, and that at the midimplant levels were performed by a single examiner (B.T.L.) and reconfirmed by the other investigator (A.B.-F.).

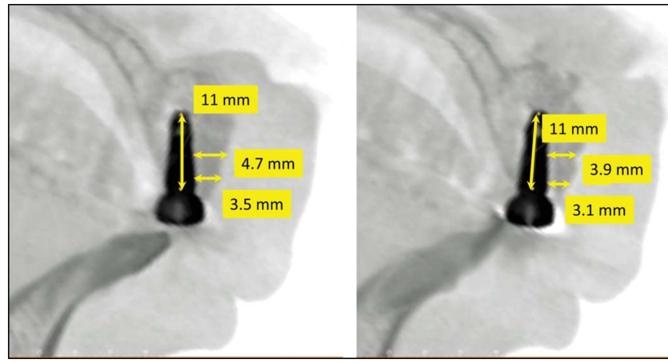

Fig. 1. Tomogram of 2 implants (8 and 9) illustrating the positions (2 mm from the bone crest and at the midimplant level) of the measurements for the thickness of the maxillary labial bone.

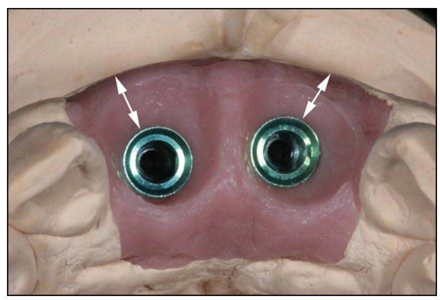

Fig. 2. CLSTT measurements performed on the study casts at the time of temporization.

Statistical Analysis

Data for the present study were entered into the Excel and subsequently transferred to the SPSS software (Statistical Package for Social Sciences Version 17.0; SPSS, Inc, Chicago, IL). CLSTT data were gender compared using the independent *t* test. Implants were divided into 2 groups based on prior bone augmentation (with bone augmentation and without). The CLSTT and labial bone thickness at the crestal and midimplant levels were exposed to independent *t* test to explore any significant differences with regards to bone augmentation. The Spearman correlation coefficients (rho) were used to assess the relationship between the implant's labial bone thickness (at the crestal and midimplant levels) and the CLSTT. Scatter plots were used to graphically explore the relationship between the implant's labial bone thickness and the CLSTT. The coefficients of determination (R^2) between the CLSTT and the implant's labial bone thickness at the crestal and midimplant levels were also calculated. Regression equations for the data were also created. Any $P < 0.05$ was considered as statistically significant.

Results

The mean ± SD for CLSTT and labial bone thickness at the crestal and midimplant levels were 2.45 ± 0.88, 1.79 ± 0.68, and 2.33 ± 1.01 mm, respectively. Overall, 26 implants had prior bone augmentation (Table 1). The CLSTT and labial bone thickness at the crestal and midimplant levels were 0.17, 0.07, and 0.23 mm, respectively, in the group without prior bone augmentation; however, the differences were not significant ($P > 0.05$). The independent *t* test revealed no significant gender difference for the CLSTT ($P > 0.05$) (2.46 ± 0.88 mm and 2.43 ± 0.90 mm for female and male patients, respectively).

There were statistically significant associations between the CLSTT and the labial bone thickness at the crestal (rho = 0.720; $P = 0.000$) and midimplant (rho = 0.707; $P = 0.000$) levels. Figures 3 and 4 show the scatter plot of the implant's labial bone thickness (at the crestal and midimplant levels) plotted against the CLSTT. The coefficients of determination (R^2) between the CLSTT and the implant's labial bone thickness at the crestal and midimplant levels were 0.649 and

$$\text{CLSTT} = 1.043^{*}\text{implant's labial bone thickness at the crestal level} + 0.586$$

$$\text{CLSTT} = 0.955^{*}\text{implant's labial bone thickness at the mid-implant level} + 0.955.$$

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Table 1. The CLSTT, and Labial Bone Thickness at Crestal and Midimplant Levels in Implants With and Without Prior Bone Augmentation

	Prior Bone Augmentation	n	Mean (SD), mm
Labial bone thickness at crestal level	Yes	26	1.75 (0.73)
	No	38	1.82 (0.66)
Labial bone thickness at midimplant level	Yes	26	2.20 (1.00)
	No	38	2.43 (1.03)
CLSTT	Yes	26	2.35 (0.91)
	No	38	2.52 (0.87)

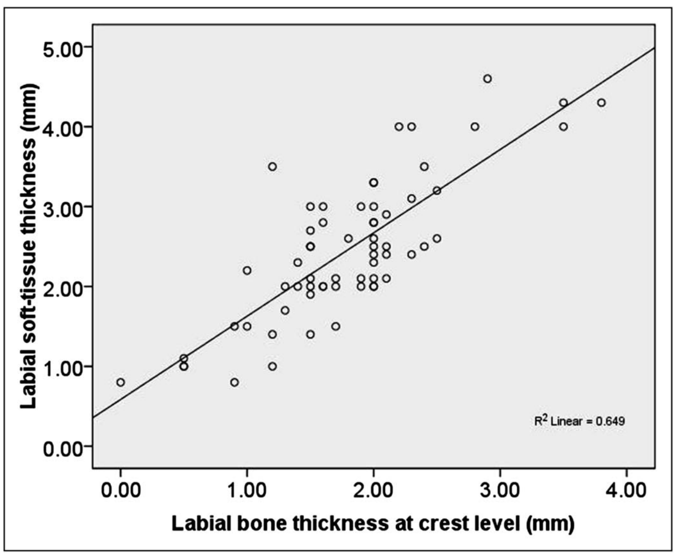

Fig. 3. Scatter plot showing the relationship between the CLSTT and the labial bone thickness at the crestal level. Solid line shows the regression lines.

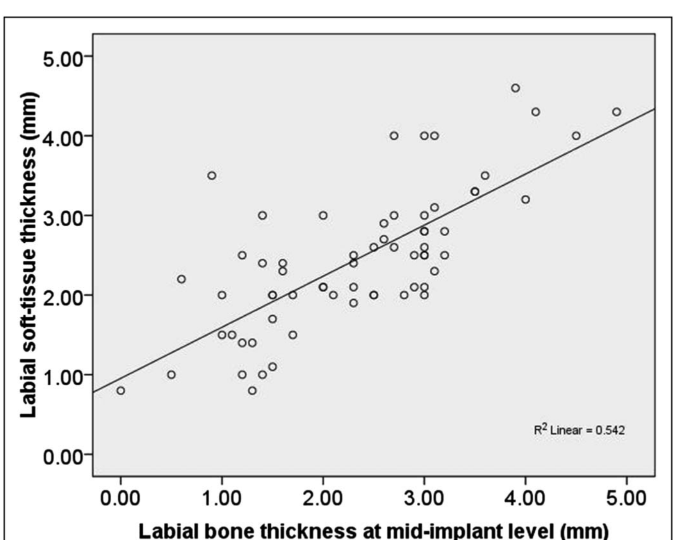

Fig. 4. Scatter plot showing the relationship between the CLSTT and the labial bone thickness at the midimplant level. Sold line shows the regression lines.

0.542, respectively. The following regression equations were produced:

DISCUSSION

Previous studies have confirmed that the level or thickness of the bone around implants can affect the soft tissue profile. For instance, the contact point location and the height of the interproximal crestal bone for a tooth or implant can influence the height of the interdental papilla.[24–28] In general, the interproximal papillae are expected to fill the embrasure area if the distance between the contact points to the interproximal crestal bone is 5 mm or less. Another example is the interimplant distance or distance between the implants and adjacent teeth. For aesthetic reasons and proper appearance of the interproximal papilla, an interimplant and an interimplant-tooth distances of 3 mm and 3 to 4 mm have been recommended, respectively.[28–31]

A thin soft tissue biotype of <2-mm thickness has often been associated with thinner underlying bone, angular bone defects, increased susceptibility to the loss of papilla after immediate implant placement, and is more prone to recession in response to trauma and bacteria than a thick biotype.[32] Consequently, a thin soft tissue biotype affects the implant success, particularly when immediate loading is the treatment of choice.[19] A minimum buccal bone thickness of 2 mm is also necessary for the maintenance of the bone level, and any thickness below that demand hard tissue bone augmentation.[20,22,32,33] However, the importance of soft tissue biotype for the prevention of gingival recession has been questioned recently.[13,34]

In the present study, high correlations (0.720 and 0.707) between the CLSTT of anterior maxillary implants and the thickness of the underlying bone in that area confirmed that the covering soft tissue was heavily influenced by the labial bone thickness. In other words, the coefficient of determination between the CLSTT and the implant's labial bone thickness at the crestal and midimplant levels and were 0.649 and 0.542, respectively. Therefore, approximately 64.9% or

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54.2% of the variation in the data for CLSTT was explained by the implant's labial bone thickness at the crestal or midimplant levels, respectively. According to the present findings, adequate labial bone thickness at the crestal level (2 mm) of anterior maxillary implants was associated with sufficient CLSTT (~2.7 mm). This is an important clinical finding because traditionally, soft tissue graft has been used to enhance the thin soft tissue coverage around the implant.[35] For the present study, we used a sectional cone beam CT scan[36] that can offer some interesting advantages such as comparable level radiation to conventional radiographs, relatively reasonable cost, and the ability to investigate the 3-dimensional image, which is lacking in conventional 2-dimensional radiographs.[37–39] Cone beam CT scan proved to be reliable in quantitatively assessing the covering buccal bone thickness in natural teeth with high precision.[40–43] A potential limitation of the study can be the difficulty in measuring the thin buccal plate facing a metallic object such as an implant. However, this method has been used previously,[44] and it is the only noninvasive approach to investigate the relationship between covering soft tissue and bone thickness.

A mean labial gingival recession of 0.5 to 1 mm around single implants, which is partially because of the bone remodeling after implant surgery, has been reported and seems to be a common finding after implant restorations.[1,18,45–49] Over 1 year between single implant placement and the second-stage surgery, a mean reduction in facial bone thickness and facial bone height of 0.4 mm and 0.7 mm have been reported, respectively, in the peri-implant tissues of the anterior maxillary region, which resulted in a mean apical displacement of 0.6 mm for the labial soft tissue margin.[48] Consequently, a limitation of this study is that we measured the CLSTT around anterior maxillary implants and the thickness of the underlying bone after 4 months, and there may be some changes after this time point. Future long-term studies can investigate these changes.

Conclusion

The findings in this study suggest the CLSTT around implants is significantly associated with the labial bone thickness in anterior maxillary region. In other words, the thicker the bone, the thicker the CLSTT around implants and vice versa.

Disclosure

The authors claim to have no financial interest, either directly or indirectly, in the products or information mentioned in the article.

Acknowledgment

Implants placed in this study were 20 Astra, 18 Strauman, 12 BHZ, 6 Zimmer, 6 Biomet, and 2 Lifecore implants. Dr Borzabadi-Farahani was supported by a research grant from the European Orthodontic Society and a Postdoctoral Research Fellowship from the Children's Hospital Los Angeles.

References

1. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. *Clin Oral Implants Res*. 2008;19:73–80.
2. Goaslind GD, Robertson PB, Mahan CJ, et al. Thickness of facial gingiva. *J Periodontol*. 1977;48:768–771.
3. Bengazi F, Wennström JL, Lekholm U. Recession of the soft tissue margin at oral implants. A 2-year longitudinal prospective study. *Clin Oral Implants Res*. 1996;7:303–310.
4. Linkevicius T, Apse P, Grybauskas S, et al. The influence of soft tissue thickness on crestal bone changes around implants: a 1-year prospective controlled clinical trial. *Int J Oral Maxillofac Implants*. 2009:24;712–719.
5. Jung RE, Sailer I, Hämmerle CH, et al. In vitro color changes of soft tissues caused by restorative materials. *Int J Periodontics Restorative Dent*. 2007;27:251–257.
6. Ngom PI, Diagne F, Benoist HM, et al. Intraarch and interarch relationships of the anterior teeth and periodontal conditions. *Angle Orthod*. 2006;76:236–242.
7. Fuhrmann R. Three-dimensional evaluation of periodontal remodeling during orthodontic treatment. *Semin Orthod*. 2002;8:23–28.
8. Wennstrom JL. Mucogingival therapy. *Ann Periodontol*. 1996;1:671–701.
9. Kassab MM, Cohen RE. The etiology and prevalence of gingival recession. *J Am Dent Assoc*. 2003;134:220–225.
10. Patel M, Nixon PJ, Chan MF. Gingival recession: part 1. Aetiology and non-surgical management. *Br Dent J*. 2011;211:251–254.
11. Richman C. Is gingival recession a consequence of an orthodontic tooth size and/or tooth position discrepancy? "A paradigm shift". *Compend Contin Educ Dent*. 2011;32:62–69.
12. Esposito M, Maghaireh H, Grusovin MG, et al. Interventions for replacing missing teeth: management of soft tissues for dental implants. *Cochrane Database Syst Rev*. 2012;(2):CD006697.
13. Chen ST, Darby IB, Reynolds EC. A prospective clinical study of non-submerged immediate implants: clinical outcomes and esthetic results. *Clin Oral Implants Res*. 2007;18:552–562.
14. Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in postextraction sites. *Int J Oral Maxillofac Implants*. 2009;24(suppl):186–217.
15. Chen ST, Darby IB, Adams GG, et al. A prospective clinical study of bone augmentation techniques at immediate implants. *Clin Oral Implants Res*. 2005;16:176–184.
16. Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapical infected sites: A prospective randomized study in 50 patients. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2006;101:705–710.
17. Kan JYK, Rungcharassaeng K, Sclar A, et al. Effects of the facial osseous defect morphology on gingival dynamics after immediate tooth replacement and guided bone regeneration: 1-year results. *J Oral Maxillofac Surg*. 2007;65(7 suppl 1) 13–19.
18. De Rouck T, Collys K, Cosyn J. Immediate single tooth implants in the anterior maxilla: a 1-year case cohort study on hard and soft tissue response. *J Clin Periodontol*. 2008;35:649–657.
19. Chen ST, Darby IB, Reynolds EC, et al. Immediate implant placement postextraction without flap elevation. *J Periodontol*. 2009;80:163–172.
20. Borzabadi-Farahani A. Orthodontic considerations in restorative management of hypodontia patients with endosseous implants. *J Oral Implantol*. [published online ahead-of-print July 5, 2011]. doi: 10.1563/AAID-JOI-D-11-00022.
21. Buser D, Martin W, Belser UC. Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. *Int J Oral Maxillofac Implants*. 2004;19(suppl):43–61.
22. Spray JR, Black CG, Morris HF, et al. The influence of bone thickness on

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facial marginal bone response: stage 1 placement through stage 2 uncovering. *Anna Periodontol*. 2000;5:119–128.

23. Nisapakultorn K, Suphanantachat S, Silkosessak O, et al. Factors affecting soft tissue level around anterior maxillary single-tooth implants. *Clin Oral Implants Res*. 2010;21:662–670.

24. Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. *J Periodontol*. 1992;63:995–996.

25. Choquet V, Hermans M, Adriaenssens P, et al. Clinical and radiographic evaluation of the papilla level adjacent to single-tooth dental implants. A retrospective study in the maxillary anterior region. *J Periodontol*. 2001;72: 1364–1371.

26. Ryser MR, Block MS, Mercante DE. Correlation of papilla to crestal bone levels around single tooth implants in immediate or delayed crown protocols. *J Oral Maxillofac Surg*. 2005;63:1184–1195.

27. Palmer RM, Farkondeh N, Palmer PJ, et al. Astra tech single-tooth implants: an audit of patient satisfaction and soft tissue form. *J Clin Periodontol*. 2007;34: 633–638.

28. Lops D, Chiapasco M, Rossi A, et al. Incidence of inter-proximal papilla between a tooth and an adjacent immediate implant placed into a fresh extraction socket: 1-year prospective study. *Clin Oral Implants Res*. 2008;19:1135–1140.

29. Esposito M, Ekestubbe A, Grondahl K. Radiological evaluation of marginal bone loss at tooth surfaces facing single Brånemark implants. *Clin Oral Implants Res*. 1993;4:151–157.

30. Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. *J Periodontol*. 2000;71:546–549.

31. Romeo E, Lops D, Rossi A, et al. Surgical and prosthetic management of interproximal region with single-implant restorations: 1-year prospective study. *J Periodontol*. 2008;79:1048–1055.

32. Lee A, Fu JH, Wang HL. Soft tissue biotype affects implant success. *Implant Dent*. 2011;20:e38–e47.

33. Le B, Burstein J. Esthetic grafting for small volume hard and soft tissue contour defects for implant site development. *Implant Dent*. 2008;17:136–141.

34. van Kesteren CJ, Schoolfield J, West J, et al. A prospective randomized clinical study of changes in soft tissue position following immediate and delayed implant placement. *Int J Oral Maxillofac Implants*. 2010;25:562–570.

35. Kan JY, Rungcharassaeng K, Lozada JL. Bilaminar subepithelial connective tissue grafts for immediate implant placement and provisionalization in the esthetic zone. *J Calif Dent Assoc*. 2005; 33:865–871.

36. Benavides E, Rios HF, Ganz SD, et al. Use of cone beam computed tomography in implant dentistry: the International Congress of Oral Implantologists consensus report. *Implant Dent*. 2012;21: 78–86.

37. De Vos W, Casselman J, Swennen GR. Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacial region: a systematic review of the literature. *Int J Oral Maxillofac Implants*. 2009;38:609–625.

38. Scarfe WC, Farman AG, Levin MD, et al. Essentials of maxillofacial cone beam computed tomography. *Alpha Omegan*. 2010;103:62–67.

39. Behneke A, Burwinkel M, Knierim K, et al. Accuracy assessment of cone beam computed tomography-derived laboratory based surgical templates on partially edentulous patients. *Clin Oral Implant Res*. 2012; 23:137–143.

40. Timock AM, Cook V, McDonald T, et al. Accuracy and reliability of buccal bone height and thickness measurements from cone-beam computed tomography imaging. *Am J Orthod Dentofacial Orthop*. 2011;140:734–744.

41. Januario AL, Duarte WR, Barriviera M, et al. Dimension of the facial bone wall in the anterior maxilla: a cone-beam computed tomography study. *Clin Oral Implants Res*. 2011;22:1168–1171.

42. Braut V, Bornstein MM, Belser U, et al. Thickness of the anterior maxillary facial bone wall-a retrospective radiographic study using cone beam computed tomography. *Int J Periodontics Restorative Dent*. 2011;31:125–131.

43. Nowzari H, Molayem S, Chiu CH, et al. Cone beam computed tomographic measurement of maxillary central incisors to determine prevalence of facial alveolar bone width ≥2 mm. *Clin Implant Dent Relat Res* [published online ahead-of-print May 11, 2010]. doi:10.1111/j.1708-8208. 2010.00287.x.

44. Roe P, Kan JY, Rungcharassaeng K, et al. Horizontal and vertical dimensional changes of peri-implant facial bone following immediate placement and provisionalization of maxillary anterior single implants: a 1-year cone beam computed tomography study. *Int J Oral Maxillofac Implants*. 2012;27: 393–400.

45. Chang M, Wennstrom JL, Odman P, et al. Implant supported single-tooth replacements compared to contralateral natural teeth. Crown and soft tissue dimensions. *Clin Oral Implants Res*. 1999;10:185–194.

46. Grunder U. Stability of the mucosal topography around single-tooth implants and adjacent teeth: 1-year results. *Int J Periodont Restorative Dent*. 2000;20: 11–17.

47. Kan JY, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. *Int J Oral Maxillofac Implants*. 2003;18:31–39.

48. Cardaropoli G, Lekholm U, Wennstrom JL. Tissue alterations at implant-supported single-tooth replacements: a 1-year prospective clinical study. *Clin Oral Implants Res*. 2006;17:165–171.

49. Jemt T, Ahlberg G, Henriksson K, et al. Changes of anterior clinical crown height in patients provided with single-implant restorations after more than 15 years of followup. *Int J Prosthodont*. 2006;19:455–461.

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